



Seal Coat
Research Project

Research

1. Report No. MN/RC - 2000-03		2.		3. Recipient's Accession No.	
4. Title and Subtitle SEAL COAT RESEARCH PROJECT				5. Report Date December 1999	
				6.	
7. Author(s) Thomas J. Wood				8. Performing Organization Report No.	
9. Performing Organization Name and Address Minnesota Department of Transportation Office of Materials and Road Research Physical Research Section 1400 Gervais Avenue Maplewood, Minnesota 55109				10. Project/Task/Work Unit No.	
				11. Contract (C) or Grant (G) No.	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard St. Paul Minnesota, 55155				13. Type of Report and Period Covered Final Report 1999	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract (Limit: 200 words) This study evaluates the use of seal coating as a method to protect bituminous pavements from oxidation, water infiltration, and raveling. The Minnesota Department of Transportation (Mn/DOT) applied seal coating to a roadway segment of Trunk Highway (TH) 21 in August 1998. The report outlines optimal requirements for the application of seal coat. Mn/DOT will continue to examine the test strip for performance and provide regular updates until the strip's condition requires reconstruction or overlay.					
17. Document Analysis/Descriptors Mn/ROAD Sealcoat Chipseal				18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified		20. Security Class (this page) Unclassified		21. No. of Pages 24	22. Price

Seal Coat Research Project

Final Report

Prepared by:

Thomas J. Wood

Minnesota Department of Transportation

Prepared for:

Office of Research and Strategic Services

Minnesota Department of Transportation

395 John Ireland Boulevard

St. Paul, MN 55155

December 1999

This report represents the results of research conducted by the author and does not necessarily represent the views or policies of the Minnesota Department of Transportation.

Sponsors

- District 6B
- Maintenance Operation Research Engineer (M.O.R.E.) Office
- Minnesota Department of Transportation's (Mn/DOT) Office of Materials and Road Research

Acknowledgements

The author would like to acknowledge the help of several people and groups whose work was instrumental to the completion of the study:

- District 6 maintenance personnel who carefully constructed the project
- City of Owatonna for use of their chip spreader and skillful operator
- New Ulm Quartzite for the numerous samples of aggregate supplied
- Koch Material for technical help
- Support from personnel of Mn/DOT's Office of Materials and Road Research
- Darlene Gorrill for assistance in report preparation

Table of Contents

Introduction	1
Design	7
Location	7
Control Section	8
Section 1	8
Special Techniques	8
Section 2	9
Section 3	9
Section 4	10
Section 5	11
Cost and Evaluation	13
Findings	15
References	17

List of Figures and Tables

Graphs

Graph 1	2
Graph 2	3
Graph 3	4
Graph 4	13

Photos

Photo 1	5
Photo 2	8
Photo 3	9
Photo 4	10
Photo 5	10
Photo 6	11
Photo 7	11
Photo 8	12
Photo 9	12

Map

Map 1	18
-------	----

Tables

Table 1	7
Table 2	19

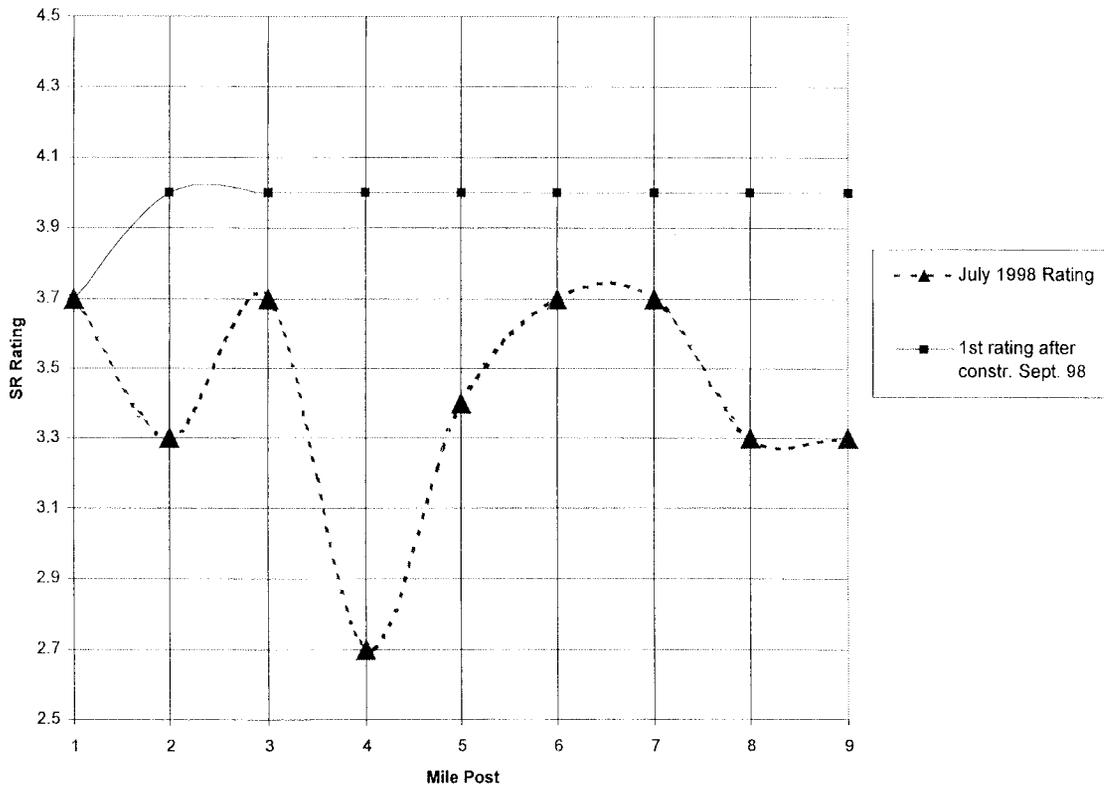
Introduction

Maintenance operations have used seal coating as a method of protecting bituminous pavements from oxidation, water infiltration, and raveling. Seal coating also increases friction numbers and improves the roadway's visual characteristic. The fear of vehicle damage from loose aggregate previously diminished the use of seal coating on higher volume roadways [>2000 average daily traffic (ADT)].

This study evaluates the use of larger size aggregates on high volume roadways (>2000 ADT), the benefit of using polymer-modified emulsion, and various design configurations including choke seal and double chip seal, as well as testing the benefits of seal coats on extending the serviceable life of a hot-mix asphalt roadway.

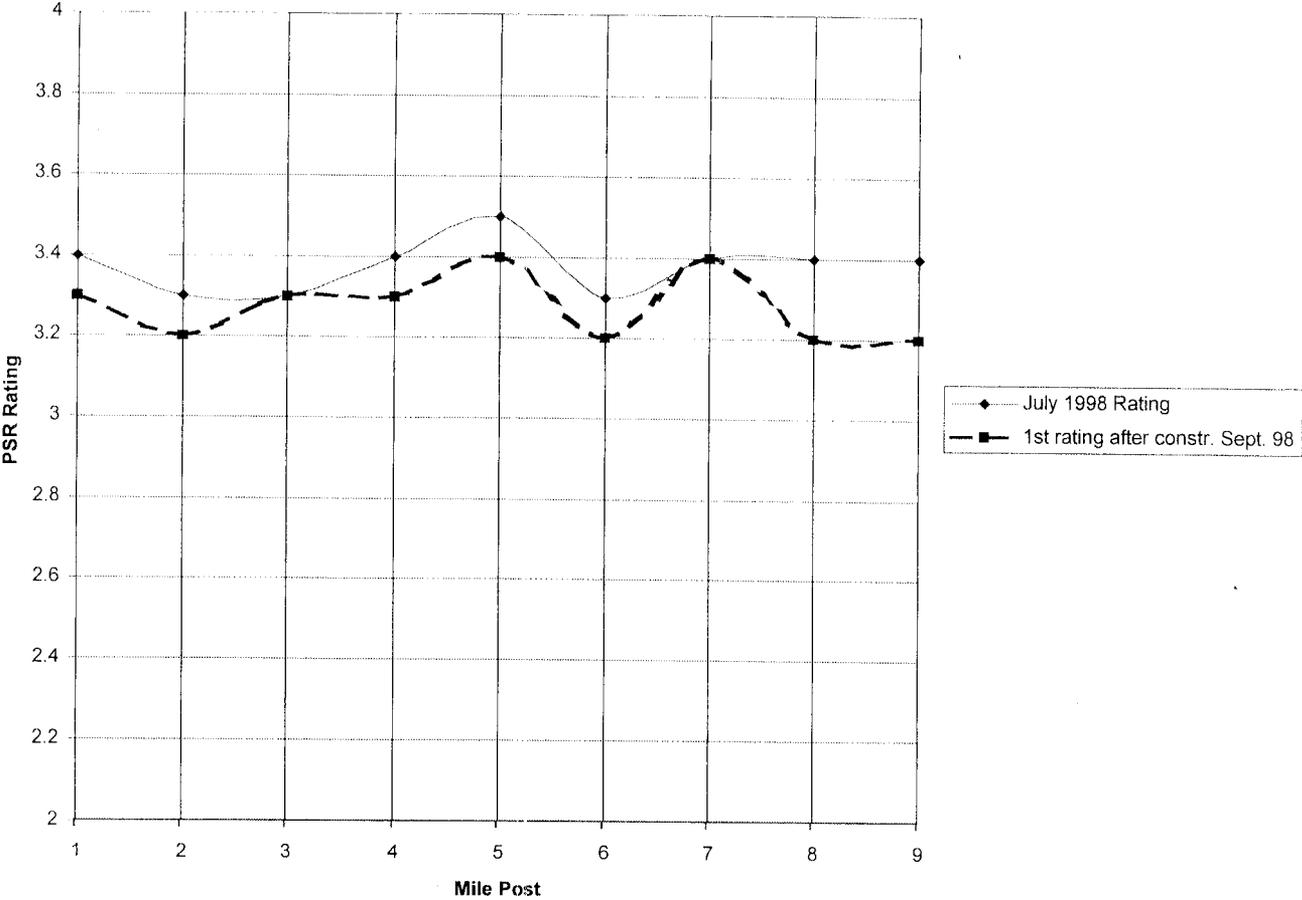
A rural two-lane highway with an ADT of 4,000, Trunk Highway (TH) 21 was last overlaid in 1991. Mn/DOT uses a pavement management system that gives ratings from data collected by a Pathways van for every state highway on a two-year schedule. Converted data produces the Surface Rating (SR), which rates surface defects. The Pavement Service Rating (PSR) provides information about the smoothness of roadway rides. Combined data from SR and PSR produces the Pavement Quality Index (PQI). Mn/DOT currently has a threshold of major replacement at 2.8 on PQI. For the PQI, PSR, and SR rating of TH 21 see **graph 1, 2, & 3**. Numerous cracks varied in size from hairline to one inch in width. **(Photo 1)** Before the seal coat, the only crack treatment involved crack filling in 1993 with AC-3, an air-blown asphalt. The smooth-riding roadway had no noticeable structural problems proved an adequate candidate for a seal coat. The surface condition before construction was oxidized, pocked, and porous. District 6B planned to seal coat this roadway segment to enhance the pavement performance and extend its usable life. Mn/DOT completed the construction in August 1998 under partly cloudy weather conditions with temperatures ranging from 65° F to 85° F and no precipitation.

SR Rating TH 21



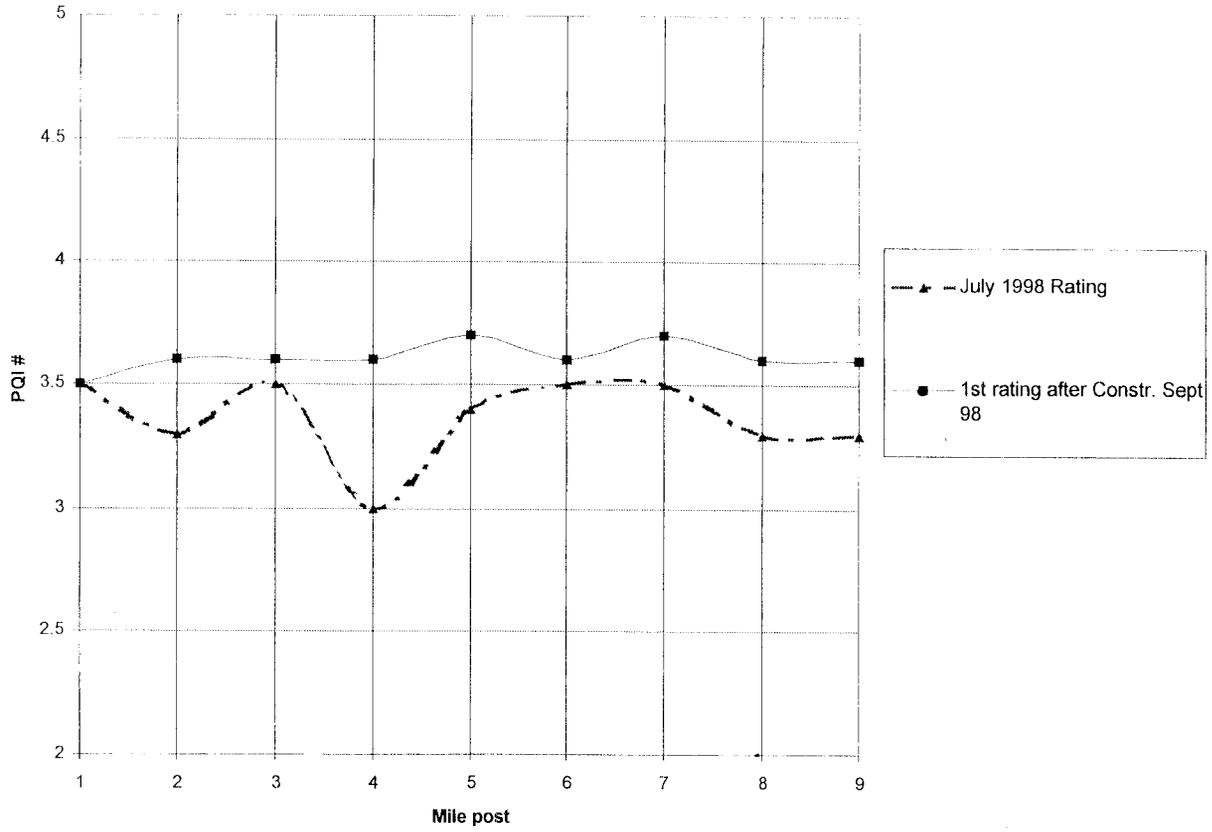
Graph 1

PSR Rating for TH 21



Graph 2

PQI Rating for TH 21



Graph 3

Photo 1

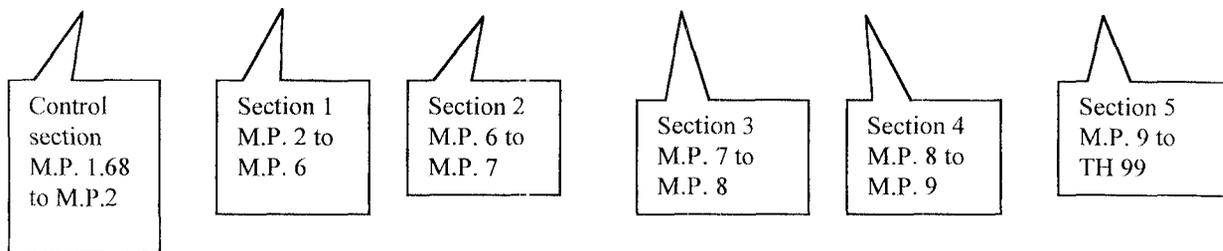
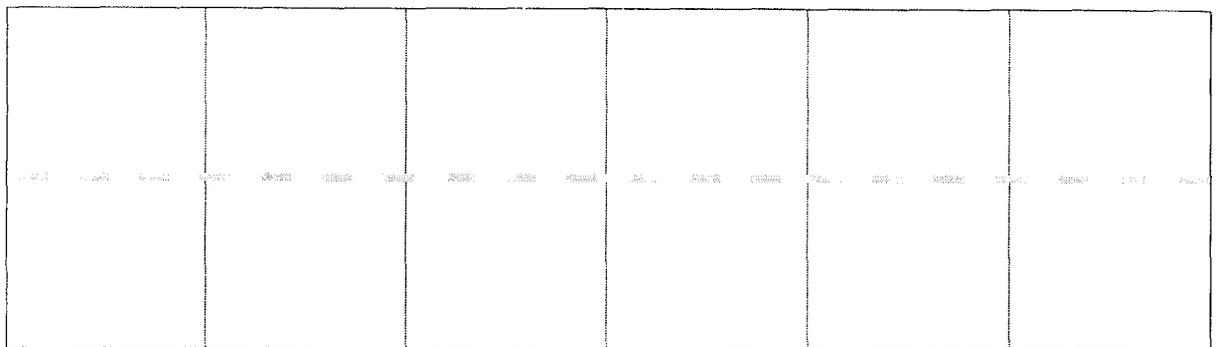


Design

Researchers used the new Mn/DOT design method to determine target application rates for both aggregate and emulsion, which were modified to take into account the ADT and current surface condition. Typically, the binder rates decrease as the ADT increase, and the binder rates increase as the surface condition deteriorates. An ADT of 4,000 required a decrease in the binder application rate. The surface condition before construction was oxidized, pocked, and porous, which required the increase in binder application rate. The sections with 7/32-inch aggregate have had additional modification to the aggregate application rate because of a high 27 percent flakiness index. The index measures flat and elongated aggregates. If the flakiness index exceeds 20 percent, then modification to the aggregate application rate also must increase. This increase in aggregate application rate allows the flat chips to double stack in the wheel paths.

Location

Trunk Highway 21 north of I-35 to TH 99. (Map 1)



North

Layout of section

Table 1

Control Section

Researchers marked a short control section on the southeast end of the project, which they left untreated to compare performance of the existing pavement and the different types of seal coats.

Section 1

Single seal coat (Photo 2): The aggregate consisted of 7/32 inch Quartzite with an emulsion of CRS-2. The design application rates were 10 lbs. / y² aggregate and emulsion applied at 0.23 gal / y².

Because of current roadway conditions and the high flakiness index of the aggregate, this section was constructed at the following rates: aggregate at 13 lbs. / y² and emulsions at 0.20 gal / y². The yield for the emulsion was measured at 0.23 gal / y².

Special Techniques

A test strip must be constructed to check the application rates for both the binder and the aggregate. One method involves the application of approximately 100 to 150 feet of binder at the design rate, followed by the placement of a layer of aggregate at the design rate. Examine the seal coat before the compaction starts to see if the binder comes up to the top of aggregate. If not, increase the binder by .02 gal / y². After completing compaction, check for extra aggregate by sweeping a roadway area with your hand. Reduce the reduction of the application rate by 1 lb / y² if loose aggregate is present. Keep repeating the test strip to determine the correct application rate for the binder and aggregate.



Photo 2

Section 2

Test section 2 consisted of a single seal with a polymer modified emulsion binder (CRS -2P). (Photo 3): Polymer modified emulsion gives greater chip retention earlier than a non-modified emulsion. It also raises the softening point of the emulsion, which helps retard bleeding on high temperature days. The cost is approximately \$.20 per gallon extra, which at this application rate equals \$.04 / y². The design rate was same as Section 1. The aggregate was 7/32 inch Quartzite applied at the rate 13 lbs. / y². The emulsion was CRS-2P applied at 0.20 gal / y².



Photo 3

Section 3

Section 3 consists of a choke seal (**Photo 4**), a traditional seal coat with the base aggregate applied at lower rate than normal. Crews apply sand made from the same aggregate source immediately after the initial aggregate application and before the rollers. A choke seal furnishes a very smooth, tight surface by filling the voids of the course aggregate with sand, eliminating chance of vehicle damage. The design rate was similar to section 1, modified as follows. Aggregate: Westbound lane 7/32 inch Quartzite applied at 11 lbs. / y² and 16X50 Quartzite sand applied at 5 lbs. / y². Emulsion design rate was 0.20 / y². CRS-2P was used on section 3. Eastbound lane design rate was the following: 7/32 inch Quartzite applied 9 lbs. / y² and 16X50 Quartzite sand applied at 5 lbs. / y². Emulsion used was CRS-2P applied at 0.18 gal / y². During construction, there was difficulty in applying the 16x50 sand. Crews used tandem axle dump trucks with winter sanders to place the sand. The choke part of seal required an application of 17.6 tons to each lane mile. The normal sander can apply only 1,500 lbs. to 2,000 lbs. per lane mile. To apply enough sand, the trucks traveled backwards with the sander set on the blast setting and made numerous trips over the roadway to place the correct amount of sand.

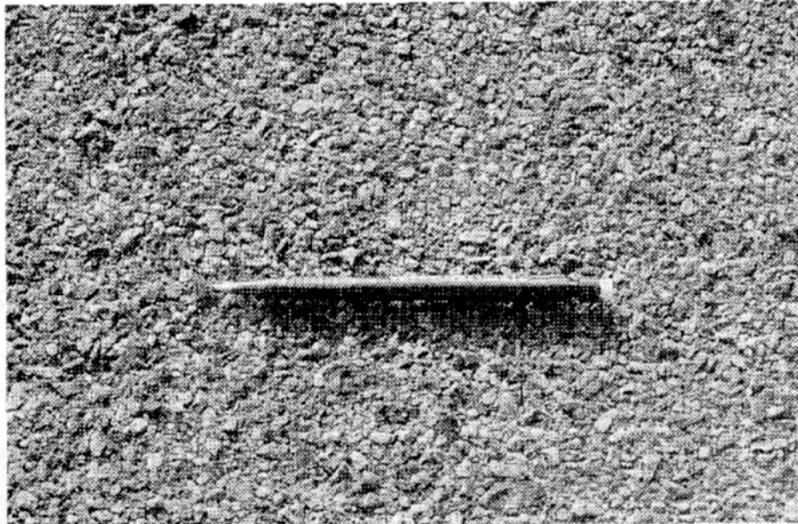


Photo 4

Section 4

This section consists of a single seal with pre-treatment coatings and polymer modified emulsions (Photo 5). The design rates were aggregate at 24lbs. / y² and emulsion at 0.33 gal / y². The aggregate used was 3/8 inch Quartzite. Because of the roadway's condition, the aggregate was applied at 18 lbs. / y² and pre-coated with a product developed by Koch Materials to increase the attraction to the emulsion. Emulsion used was a specially modified CRS-2P applied at 0.35 gal / y².



Photo 5

Section 5

Section 5 is a double seal (**Photo 6**), which consist of two applications of emulsion and aggregate. The first aggregate applied should be approximately twice as large as the aggregate used in the second application. Determining the total emulsion rate needed involves designing each coating like a single seal coat then adding the total amount of emulsion needed together. The first application rate is 60 percent of the total. The second application is 40 percent. The design rates for the double seal was 26 lbs. / y² of 1/2 inch Quartzite (Ostrich grit), 10 lbs. / y² of 7/32-inch Quartzite chips, and 0.50 gal/ y² of CRS-2P. Because of the roadway's condition and the flakiness index of the 7/32 inch Quartzite, the rates were adjusted to the following: First course aggregate 1/2 inch Quartzite was applied at 19 lbs. / y². Emulsion was applied at 0.30 gal / y² (**Photo 7**). The second course aggregate 7/32 inch Quartzite was applied at 14 lbs. / y² (**Photo 8**). The second application of emulsion was applied at 0.20 gal / y² (**Photo 9**).



Photo 6

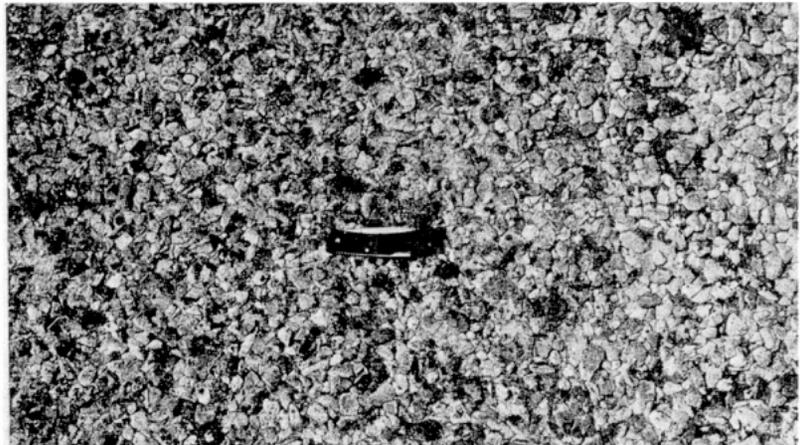


Photo 7



Photo 8

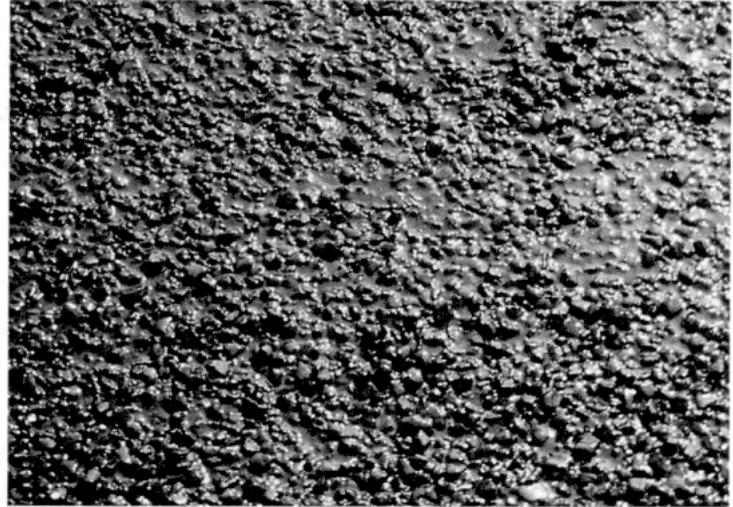
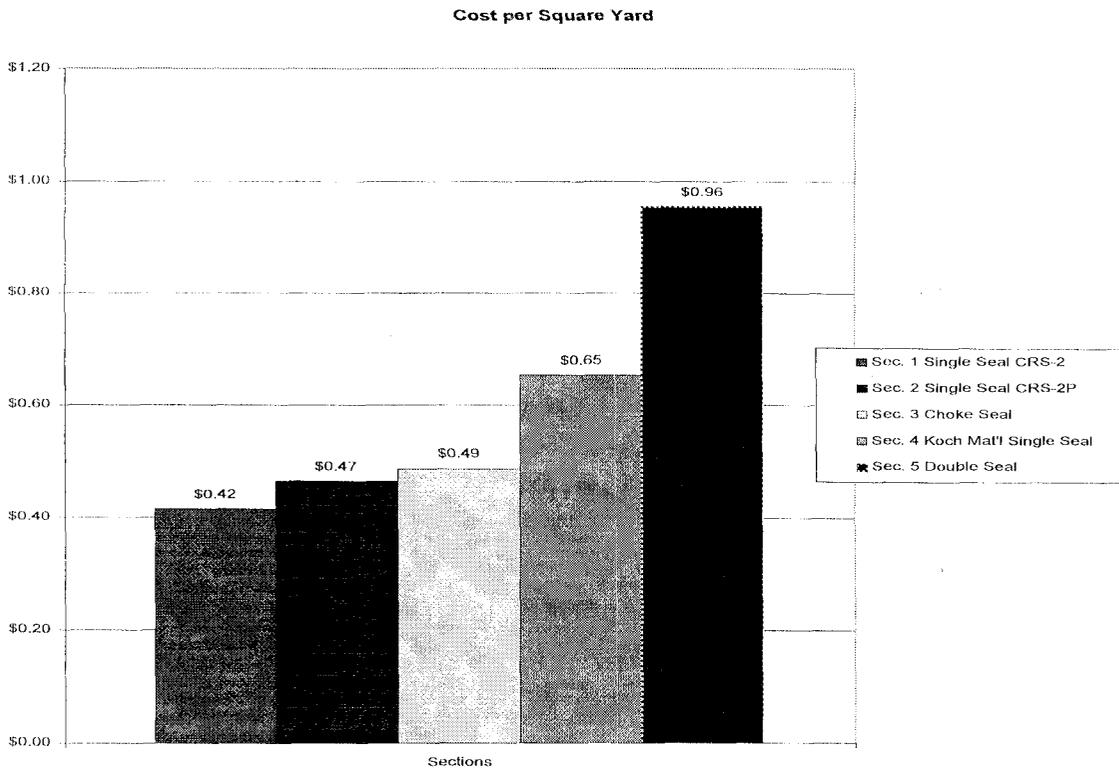


Photo 9



Graph 4

Cost and Evaluation

Graph 4 shows the cost comparisons of the test sections, based on estimates from maintenance accounting data. These prices include materials, equipment, and labor. Mn/DOT's maintenance forces completed all work.

The evaluation will consist of collecting pavement conditions rating using pavement management criteria. The surface rating (SR) and ride (PSR) (**graph 1, 2, & 3**) will be taken twice a year to monitor any changes. Friction tests also will be conducted twice a year in the fall and spring. Testing to determine loss of aggregates will be conducted annually. Visual observation will be conducted on an ongoing basis.

Metro Division's traffic services unit will study the effectiveness of epoxy paint on seal coats.

Findings

It has become apparent that the small details are very important to the success of any project. Taking care in completing the following steps greatly increases the chances of success.

1. Make sure pavement is clean.
2. Use high quality materials.
3. Proper application rate for binder.
4. Proper application rate for aggregates. Extra aggregates only cause failure.
5. Keep distance between the distributor and the chipper at a minimum. Aggregates must be applied to the emulsion before it starts to break.
6. Minimum of three rollers. Keep speed under 5 miles per hour. Complete rolling before emulsion is broken.
7. Complete final sweeping of roadway as soon as possible and no later than the next morning.

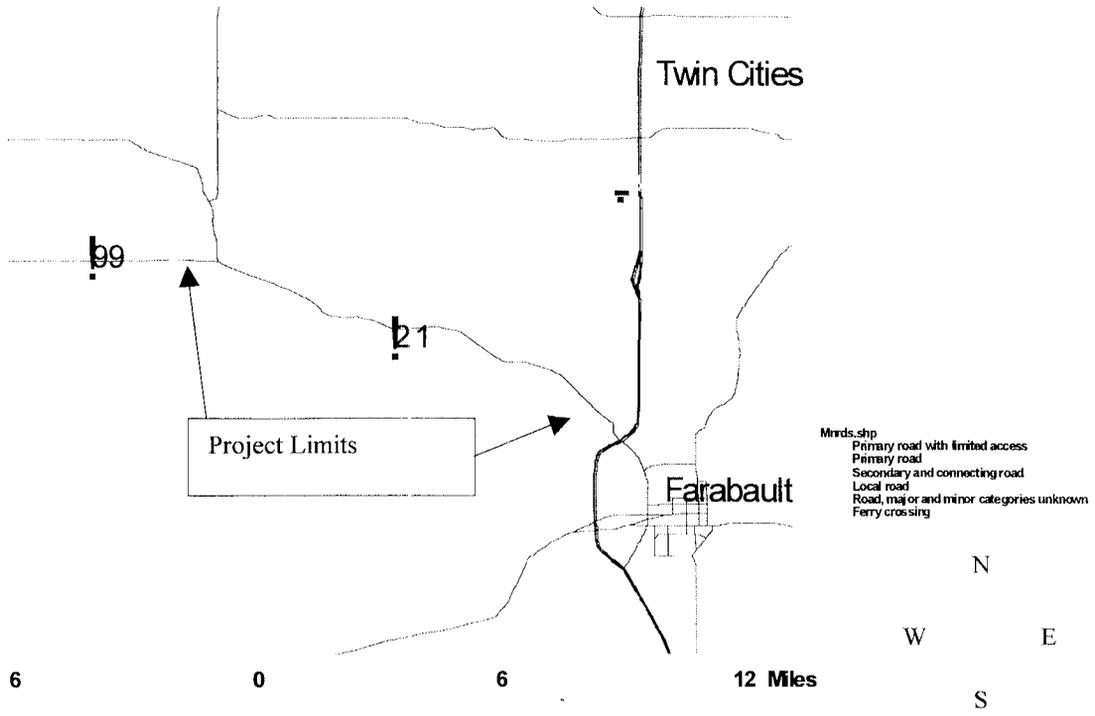
The polymer-modified emulsion (CRS-2P) appeared to enhance early chip retention. The early conclusion about using epoxy paint is that application rates must be increase to fill voids present in the surface.

The performance properties of the test sections will continue to be evaluated, and regular updates to this initial report will be published. The evaluations continue until TH 21 is overlaid or re-constructed.

References

Janisch, D. W., Gaillard, F. S., *Minnesota Seal Coat Handbook*, Minnesota Department of Transportation MN/RC – 1999-07

TH 21 Seal Coat Project



Map 1

The following test sections were constructed on the project. The application rates given were the target values, due to equipment problems some of the emulsion application varied.

TEST SECTION	MILEPOST	AGGREGATE MAX. SIZE IN. APPLICATION RATE			ASPHALT	
		TYPE	MAX. SIZE IN.	RATE LB/Y ²	TYPE	RATE GAL/Y ²
Control Section	1.5 - 2	None	N. A.	N. A.	N. A.	N. A.
1	2-6	QUARTZITE	7/32 inch	13	CRS-2 ¹	0.20
2	6-7	QUARTZITE	7/32 inch	13	CRS-2P	0.20
3	7-8 WESTBOUND	QUARTZITE	7/32 inch #15 BY #60 SAND	11 5	CRS-2P	0.20
3	7-8 EASTBOUND	QUARTZITE	7/32 inch #15 BY #60 SAND	9 5	CRS-2P	0.18
4	8-9	QUARTZITE PRE-COATED	3/8 inch	18	MOD. CRS-2P	0.35
5 A*	9 to TH99	QUARTZITE	1/2 inch	19	CRS-2P	0.30
5 B*	9 to TH99	QUARTZITE	7/32 inch	14	CRS-2P	0.20

Table 2

¹ EXCEPT FROM MILEPOST 2.5 TO 2 ON THE WESTBOUND SIDE IS CRS-2P

* DOUBLE SEAL 5A IS FIRST COURSE. 5B IS SECOND COURSE.



Office of Research & Strategic Services
395 John Ireland Blvd., Mail Stop 330
Saint Paul, Minnesota 55155



(651) 282-2274